CAPSTONE PROJECT

STOCK PRICE PREDICTION SYSTEM

TEAM H

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Contents

Project Objectives

Stock Price Prediction System

- ✓ **Using AI Models – LSTM, GRU, Transformer**
  - Specialized for sequential data(time series data) analysis
- ✓ **Front-end Implementation**
  - Visualize real and predictive graphs through website development
- ✓ **Not Real-Time**

Project Objectives

What is the difference with existing services?

SK C&C, '마켓캐스터 AIST' 활용한 실제 'AI 투자 전략 서비스' 개발... 상용화 위한 검증도 진행

- ✓ **There are already many stock investment services using AI**
  - But they care about the stable distribution and management of assets of the users

Project Objectives

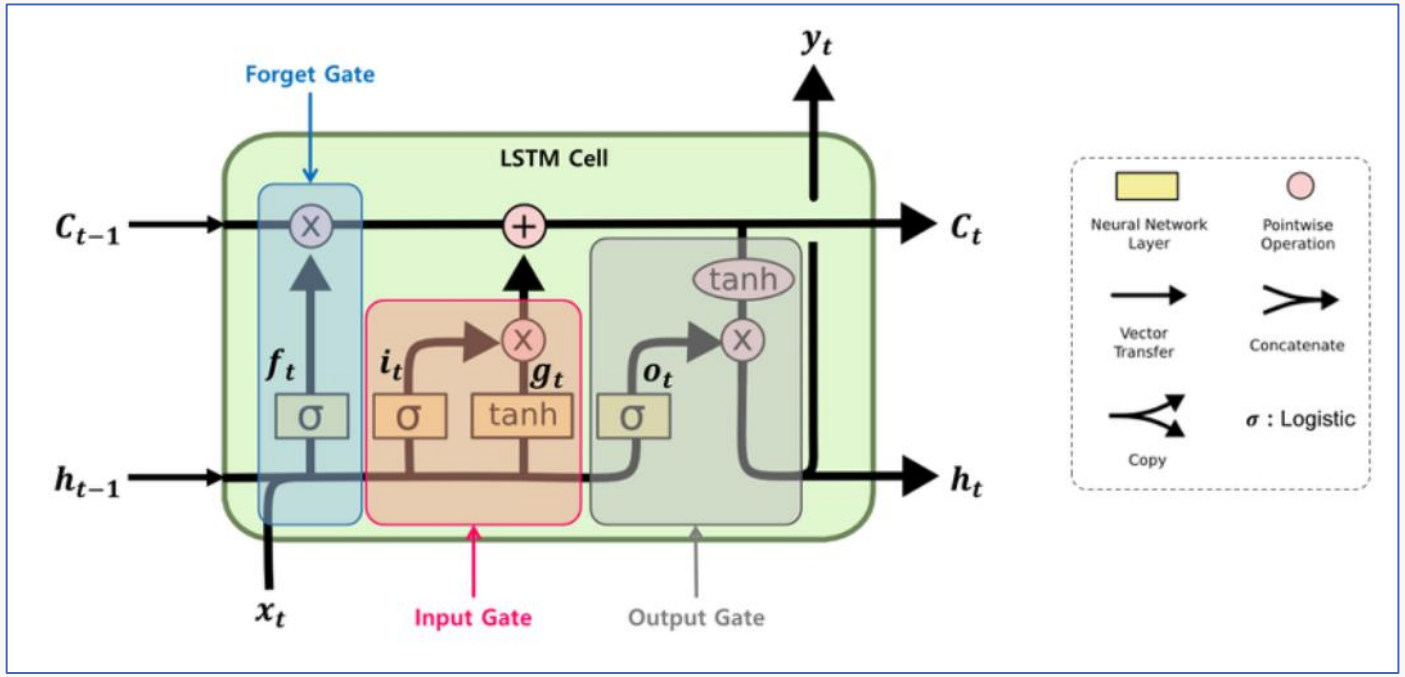
So, we decided to focus only on improving the predictive performance…

- ✓ **Because it is hard to implement many functions due to the limited cost and time given**

AI Models & Programs

LSTM (Long Short Term Memory)

✓ **Solves gradient vanishing problem of existing RNN when input data is too long**



AI Models & Programs

LSTM (Long Short Term Memory)

✓ **Solves gradient vanishing problem of existing RNN when input data is too long**

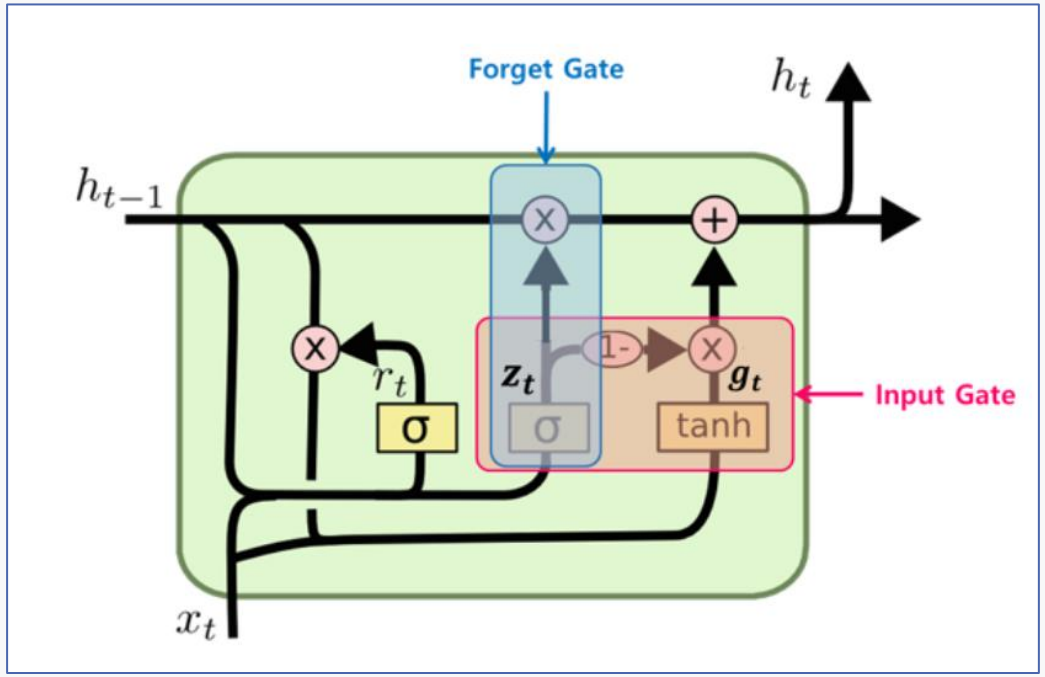
```
class FinanceLSTM(nn.Module):

    def __init__(self, model_args):

        super(FinanceLSTM, self).__init__()

        self.output_length = model_args.output_length
        self.num_layers = model_args.num_layers
        self.input_size = model_args.input_size
        self.hidden_size = model_args.hidden_size
        self.fc_hidden_size = model_args.fc_hidden_size
        self.device = model_args.device

        self.lstm = nn.LSTM(input_size = self.input_size, hidden_size = self.hidden_size,
                            num_layers = self.num_layers, batch_first = True)
        self.fc1 = nn.Linear(self.hidden_size, self.fc_hidden_size)
        self.fc2 = nn.Linear(self.fc_hidden_size, self.output_length)
        self.act = nn.ELU()
```

```
def forward(self, x):

    h_0 = torch.Tensor(torch.zeros(self.num_layers, x.size(0), self.hidden_size)).to(self.device)
    c_0 = torch.Tensor(torch.zeros(self.num_layers, x.size(0), self.hidden_size)).to(self.device)

    output, (hn, cn) = self.lstm(x, (h_0, c_0))
    hn = hn.view(-1, self.hidden_size)
    logits = self.act(hn)
    logits = self.fc1(logits)
    logits = self.act(logits)
    logits = self.fc2(logits)
    return logits
```

AI Models & Programs

GRU (Gated Recurrent Unit)

✓ A version of simplifying the time-step cell that makes up the LSTM



AI Models & Programs

GRU (Gated Recurrent Unit)

✓ **A version of simplifying the time-step cell that makes up the LSTM**

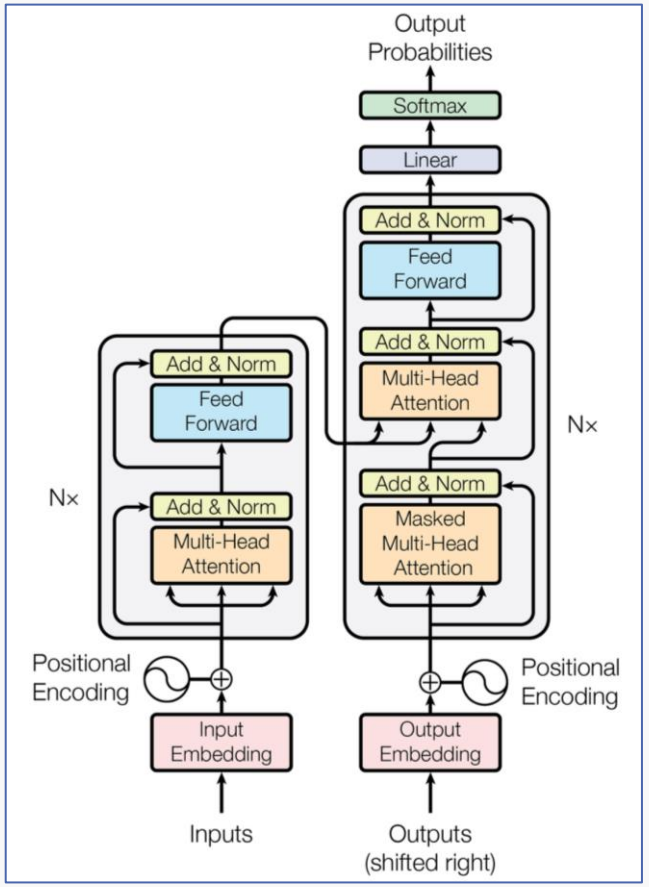
```
class FinanceGRU(nn.Module):

    def __init__(self, model_args):

        super(FinanceGRU, self).__init__()

        self.output_length = model_args.output_length
        self.num_layers = model_args.num_layers
        self.input_size = model_args.input_size
        self.hidden_size = model_args.hidden_size
        self.fc_hidden_size = model_args.fc_hidden_size
        self.device = model_args.device

        self.gru = nn.GRU(input_size = self.input_size, hidden_size = self.hidden_size,
                          num_layers = self.num_layers, batch_first = True)
        self.fc1 = nn.Linear(self.hidden_size, self.fc_hidden_size)
        self.fc2 = nn.Linear(self.fc_hidden_size, self.output_length)
        self.relu = nn.ReLU()
```

```
def forward(self, x):
    h_0 = torch.Tensor(torch.zeros(self.num_layers, x.size(0), self.hidden_size)).to(self.device)
    output, (hn) = self.gru(x, (h_0))
    hn = hn.view(-1, self.hidden_size)
    logits = self.relu(hn)
    logits = self.fc1(logits)
    logits = self.relu(logits)
    logits = self.fc2(logits)

    return logits
```

AI Models & Programs

Transformer

- ✓ **Parallel processing is possible by putting the sequence at once, and location information can be reflected**



AI Models & Programs

Transformer

- ✓ **Parallel processing is possible by putting the sequence at once, and location information can be reflected**

```python
class FinanceTransformer(nn.Module):

    def __init__(self, model_args):

        super(FinanceTransformer, self).__init__()

        self.embed_dim = model_args.embed_dim
        self.resolution = model_args.resolution
        self.n_head = model_args.n_head
        self.n_layer = model_args.n_layer
        self.fc_hidden_size = model_args.tf_fc_hidden_size
        self.seq_length = model_args.seq_length
        self.output_length = model_args.output_length
        self.input_size = model_args.tf_input_size
        self.device = model_args.device

        embed_args = EmbeddingArgs(embed_dim=self.embed_dim, resolution=self.resolution)
        self.embed = FinanceEmbedding(embed_args)

        self.encoder_layer = nn.TransformerEncoderLayer(d_model=self.embed_dim*(self.input_size-1), nhead=self.n_head, batch_first=True)
        self.encoder = nn.TransformerEncoder(encoder_layer = self.encoder_layer, num_layers=self.n_layer)
        self.fc1 = nn.Linear(self.embed_dim*self.seq_length*(self.input_size-1), self.fc_hidden_size)
        self.fc2 = nn.Linear(self.fc_hidden_size, self.output_length)
        self.act = nn.ELU()
        self.flat = nn.Flatten()
```

```python
def forward(self, x):
    x = self.resolution_map(x)
    embed_x = self.embed(x)
    enc_x = self.flat(self.encoder(embed_x))
    logits = self.fc1(enc_x)
    logits = self.act(logits)
    logits = self.fc2(logits)
    return logits
```

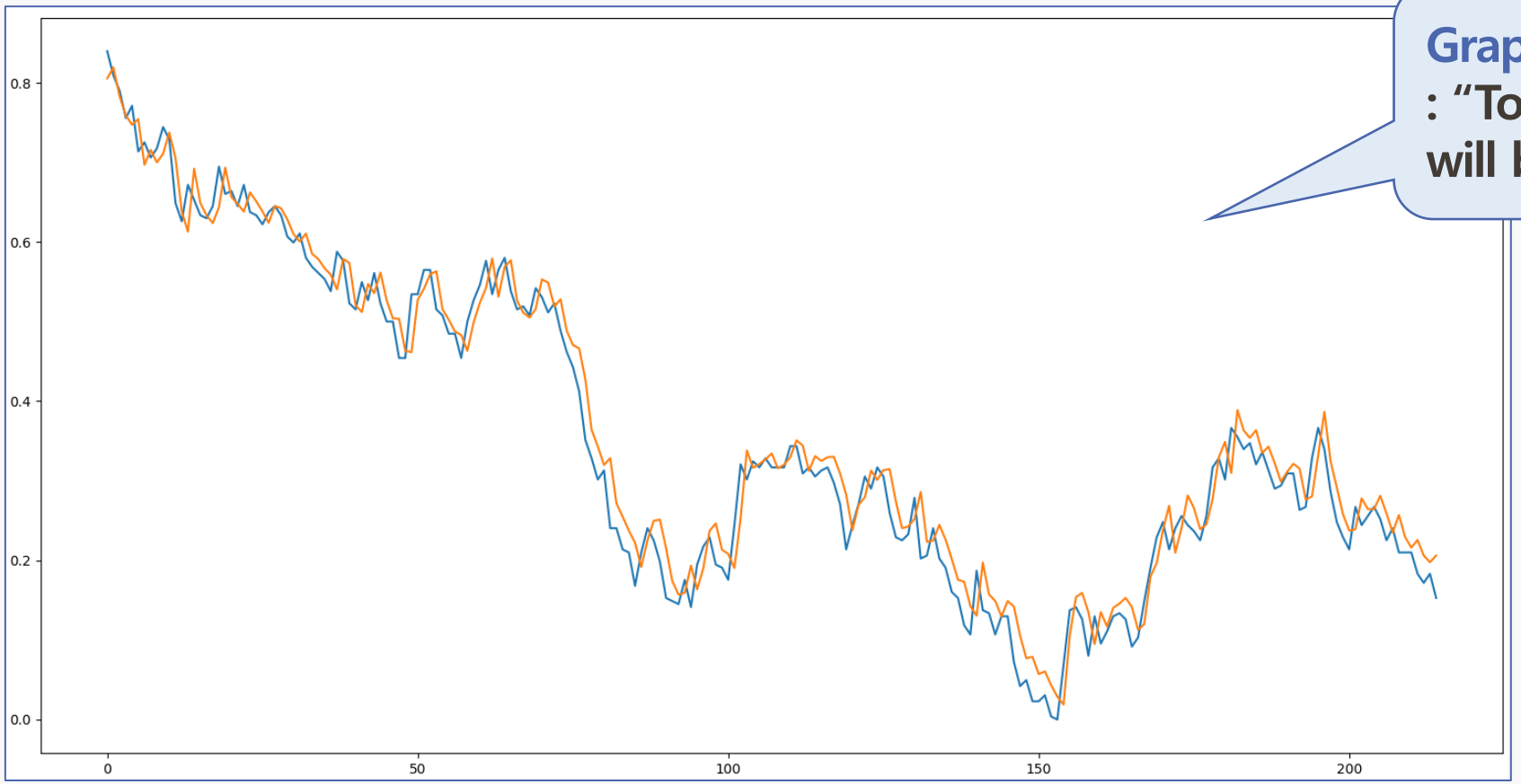
AI Models & Programs

Backend Programs

AI Models & Programs

Frontend Programs

Challenges & Progress



Graph Shifting
: "Tomorrow's stock price will be Today's stock price"

Challenges & Progress

Problem: Graph Shifting

Solution: Apply more diverse features to predictions

Progress: Apply **VADER score** of stock market articles

```
[5]  import pandas as pd
     import nltk
     from nltk.sentiment.vader import SentimentIntensityAnalyzer

[6]  nltk.download('vader_lexicon')
     sentiment = SentimentIntensityAnalyzer()

     [nltk_data] Downloading package vader_lexicon to /root/nltk_data...
     [nltk_data]   Package vader_lexicon is already up-to-date!

[7]  sentiment.polarity_scores('good good good')

     {'neg': 0.0, 'neu': 0.0, 'pos': 1.0, 'compound': 0.8271}

     sentiment.polarity_scores('Memory Market: It is judged to enter the low-demand phase such as PC and mobile. Demand for some builds appears.')

     {'neg': 0.073, 'neu': 0.927, 'pos': 0.0, 'compound': -0.128}
```

Challenges & Progress

Problem: Graph Shifting

- **Solution:** Train models with another stock data
  - **Progress:** Increase the dataset and divide it into 4 categories

Korea Stable
Samsung Electronics Co Ltd
Samsung SDI Co Ltd
KT&G Corp
Yuhan Corp
SK Hynix Inc
DB Insurance Co Ltd
Korea Zinc Inc
Fila Holdings Corp
Meritz Financial Group Inc
Cheil Worldwide Inc
LG Innotek Co Ltd
Shinsegae Inc
IBK
NCSoft Corp
Lotte Chemical Corp
Leeno Industrial Inc
Nongshim Co Ltd
S1 Corp
Hyundai Marine & Fire Insurance Co. Ltd.

Korea unstable
Posco Holdings Inc
Naver Corp
Hyundai Motor Co
LG Chem Ltd
Kia Corp
Celltrion Inc
KB Financial Group Inc
Shinhan Financial Group Co Ltd
LG Energy Solution Ltd
Kakao Corp
HYUNDAI MOBIS CO., LTD.
Samsung C&T Corp
Samsung Biologics Co Ltd
LG Electronics Inc
Hana Financial Group Inc

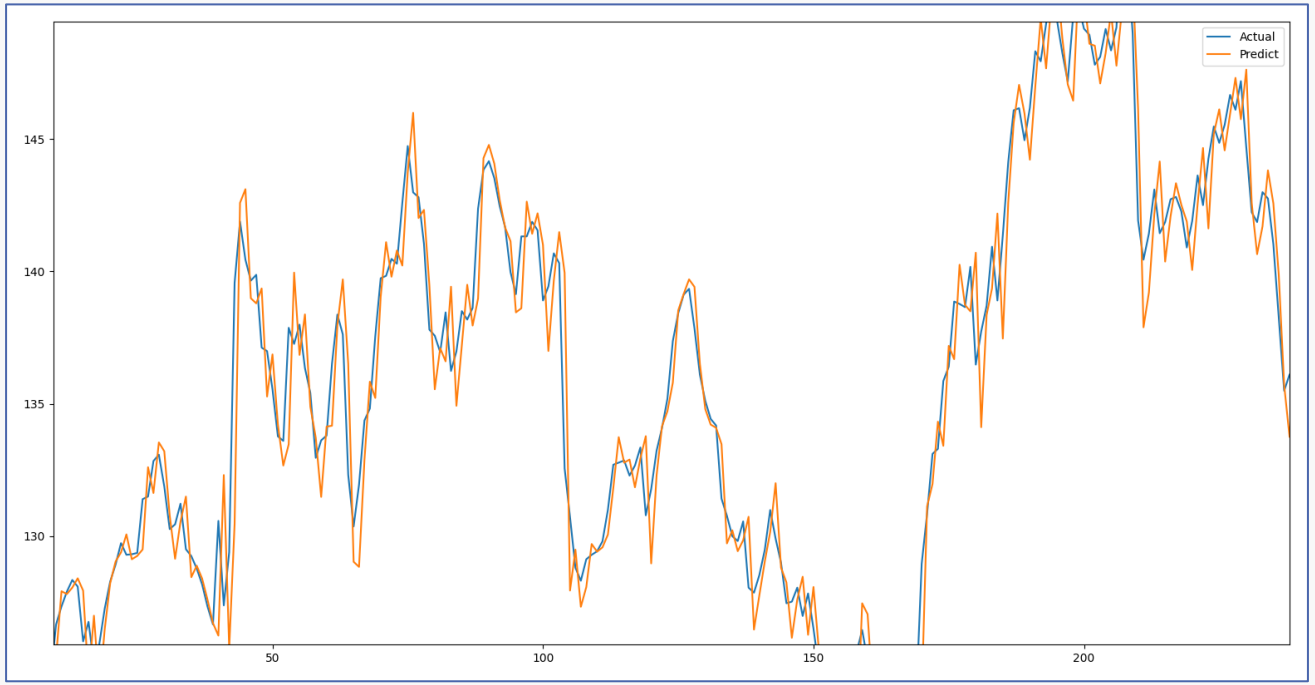
US Nasdaq Stable
Coca-Cola Co
McDonald's Corp
Waste Management, Inc.
Republic Services Inc
PepsiCo, Inc.
Colgate-Palmolive Company
Walmart Inc
Cboe Global Markets Inc
General Dynamics Corp
Kimberly-Clark Corp
Procter & Gamble Co
Cencora Inc
IBM Common Stock

US Nasdaq unstable
Apple Inc
Microsoft Corp
Amazon.com Inc
NVIDIA Corp
Meta Platforms Inc
Broadcom Inc
Alphabet Inc Class A
Alphabet Inc Class C
Tesla Inc
Adobe Inc
Costco Wholesale Corporation
Cisco Systems Inc
Netflix Inc
Advanced Micro Devices, Inc.

Challenges & Progress

Problem: Graph Shifting

- **Solution:** Make some changes in the learning rate of the models
  - **Progress:** Apply learning rate scheduler to prediction system



Demo

Stock Name

Next Stock Price (Prediction)

Tomorrow changes (Prediction)

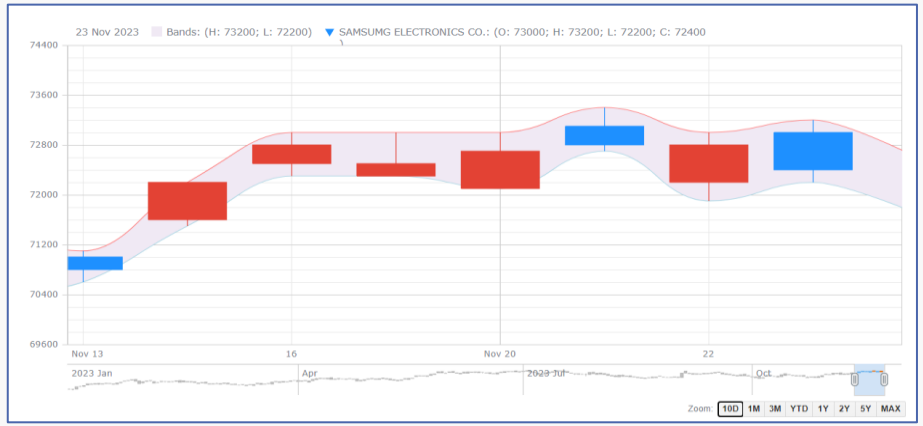
Demo

Stock price visualization with candle chart

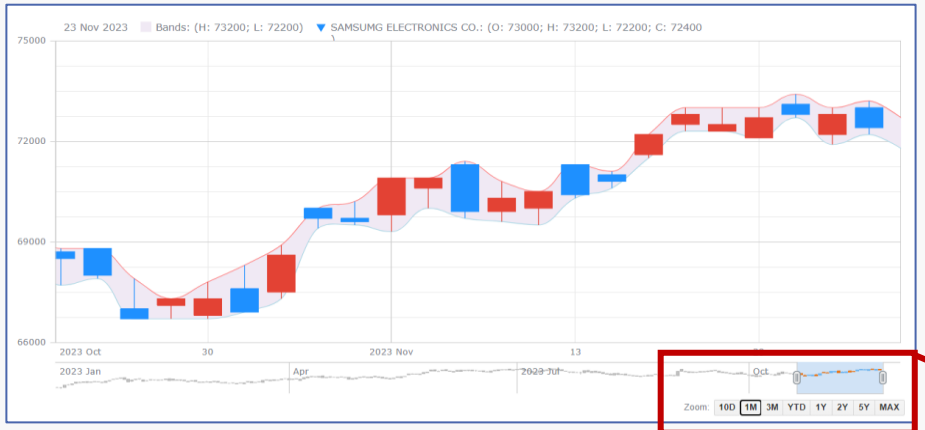
Prediction range: high - low

Stock information for each date

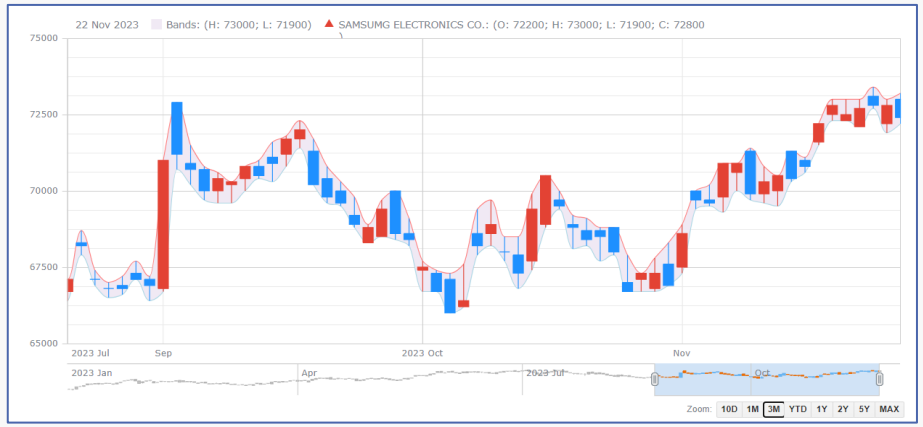
Demo



Period: 10 days

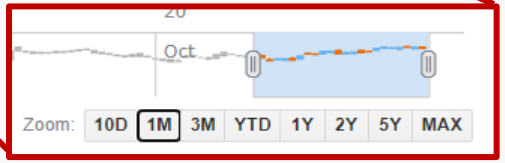


Period: 1 month



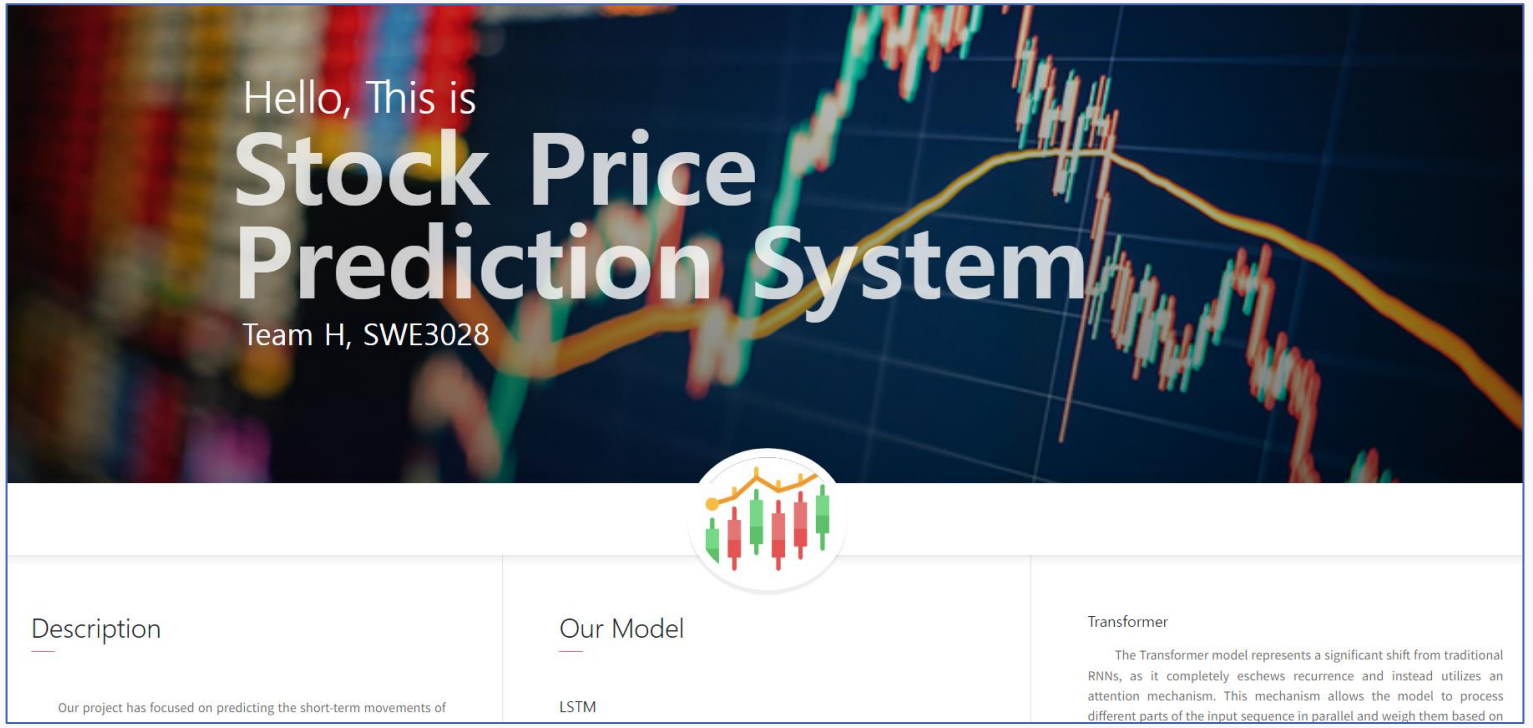
Period: 3 months

Period: 2 years



User can select the period with buttons or time scrollbar

Demo



http://3.34.75.210:8000/

We recommend you to use the website with laptop

Result & Discussion

$$\mathrm{MPA}_t = 1 - \frac{1}{N}\sum_{i=1}^{N}\frac{|\hat{y}_i - y_i|}{y_i}$$

$$\mathrm{MAE}_t = \frac{1}{N}\sum_{i=1}^{N}|\hat{y}_i - y_i|$$

$$\mathrm{TA}_t = \frac{1}{N}\sum_{i=1}^{N}\mathbb{1}(\mathrm{sign}(\hat{y}_i - \hat{y}_{t-1}) = \mathrm{sign}(y_i - y_{t-1}))$$

$$\mathrm{Accuracy}_t = \frac{1}{N}\sum_{i=1}^{N}\frac{\mathrm{length}(\{y_{\min} < y < y_{\max} \cap \hat{y}_{\min} < y < \hat{y}_{\max}\})}{\max(\mathrm{length}(\hat{y}_{\min} < y < \hat{y}_{\max}), \mathrm{length}(y_{\min} < y < y_{\max}))}$$

Accuracy measurement method

1. **MPA** & **MAE**: Evaluate the effectiveness of our methods
2. **TAC**: Focus on short-term stock price trends
3. **Accuracy**: Compare the similarity between the predicted and actual price intervals

Result & Discussion

		STABLE				UNSTABLE			
Model		MPA	MAE	TAC	ACC	MPA	MAE	TAC	ACC
LSTM	High	0.9922	1.2179	0.5640	0.4183	0.9856	4.2027	0.5872	0.4163
	Low	0.9921	1.1985	0.5702		0.9851	4.1493	0.5711	
GRU	High	0.9929	1.1118	0.5640	0.4340	0.9864	3.9909	0.5930	0.4199
	Low	0.9926	1.1193	0.5659		0.9862	3.8426	0.5747	
Transformer	High	0.9906	1.4721	0.4743	0.4295	0.9827	5.2046	0.4731	0.3374
	Low	0.9892	1.6502	0.5361		0.9830	4.8531	0.4616	
BASELINE		0.9815				0.9815			

- ✓ Performance of our models on the test set is quantified.

Result & Discussion

Model		STABLE MPA	STABLE MAE	STABLE TAC	STABLE ACC	UNSTABLE MPA	UNSTABLE MAE	UNSTABLE TAC	UNSTABLE ACC
LSTM	High	0.9922	1.2179	0.5640	0.4183	0.9856	4.2027	0.5872	0.4163
	Low	0.9921	1.1985	0.5702		0.9851	4.1493	0.5711	
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	Low	0.9892	1.6502	0.5361		0.9830	4.8531	0.4616	
BASELINE		0.9815				0.9815			

- ✓ Our prediction system has resulted in MPA surpassing that of the baseline model (DP-LSTM).
- ✓ **It seems that our progress has the effect of increasing prediction accuracy.**

Result & Discussion

Model		STABLE MPA	STABLE MAE	STABLE TAC	STABLE ACC	UNSTABLE MPA	UNSTABLE MAE	UNSTABLE TAC	UNSTABLE ACC
LSTM	High	0.9922	1.2179	0.5640	0.4183	0.9856	4.2027	0.5872	0.4163
	Low	0.9921	1.1985	0.5702		0.9851	4.1493	0.5711	
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BASELINE		0.9815				0.9815			

- ✓ The model's performance varies based on the stability of the stocks. For unstable stocks, the MAE significantly increases, and ACC decreases.

Result & Discussion

		STABLE				UNSTABLE			
Model		MPA	MAE	TAC	ACC	MPA	MAE	TAC	ACC
LSTM	High	0.9922	1.2179	0.5640	0.4183	0.9856	4.2027	0.5872	0.4163
	Low	0.9921	1.1985	0.5702		0.9851	4.1493	0.5711	
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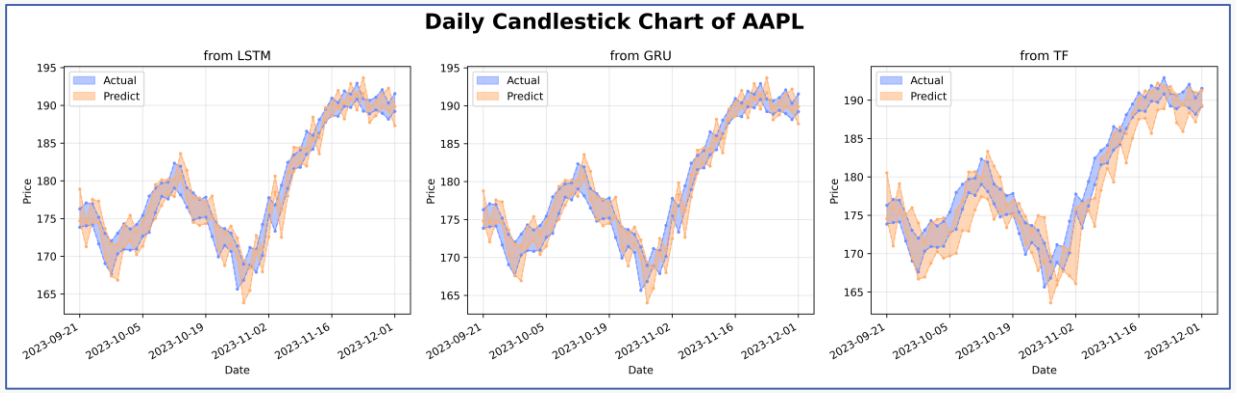
	Low	0.9892	1.6502	0.5361		0.9830	4.8531	0.4616	
BASELINE		0.9815				0.9815			

- ✓ Both LSTM and GRU models exhibit similar performance metrics, whereas the Transformer model has relatively lower performance.

Result & Discussion

Limitations: Prediction Quality



- ✓ **Increased inaccuracies for specific cases**
  - Problem arises when the stock price remains relatively constant with minor fluctuations (2023-11-16 to 2023-12-01)
  - In the case of Transformers, the high-priced and low-priced sections are uneven

Result & Discussion

Limitations: Lack of Information

- ✓ **Imbalance of news articles**
  - Famous stocks have a lot of related information, but obscure stocks update less and slower
- ✓ **Articles written in a limited period of time**
  - The referenced news site's articles are limited to maximum 1,000 per stocks

Roles

Donghun Jung

- AWS server build
- UI/UX Design
- Backend Implementation
- Documentation (Proposal, Final)

Chanyoung Lee

- LSTM Development
- Transformer Development
- Model Improvement

Yujin Seo

- GRU Development
- VADER Development
- Collecting Stock News

Time Table

	Week 03	Week 04	Week 05	Week 06	Week 07	Week 08
Donghun Jung	Proposal		AWS Server Build			
Chanyoung Lee	LSTM Development			Model Improvement		
Yujin Seo	GRU Development			Search Paper and Research		

	Week 09	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
Donghun Jung	UI/UX Design		Backend Implementation				Report
Chanyoung Lee	Transformer Development		Hyperparameter Tuning		Testing		Final Testing
Yujin Seo	VADER Development				Collecting Stock News		

Any Question?